Digital Signal Processing procedures of Ultrasonic and 3-D Terrestrial Laser Scanner data in the diagnostics of monumental structures

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A new non-destructive methodology based on the experimental application of integrated use of 3-D terrestrial laser scanning (3-D TLS) and ultrasonic techniques in the range (54-82 kHz) in evaluating the quality of stone building materials in monumental structures has provided satisfactory results.
In this paper our target is to evaluate the state of conservation of the previously described materials by correlating the ultrasonic measurement results with the reflectivity of the reflected 3-D laser scanner beam pulse transmitted to the target of an investigated surface.
Ultrasonic methods are very effective in detecting the elastic characteristics of stone materials and thus their mechanical behaviour even though data interpretation is very complex as elastic wave velocity depends on moisture, heterogeneity, porosity and other physical properties. The study of the propagation of the longitudinal ultrasonic pulses is improved from the digital signal processing which allows to obtain information from the wavetrains. Therefore accurate ultrasonic analyses based not only on longitudinal pulse velocity analysis but also on frequency spectra and cross-spectra analyses allowed to improve the results of the diagnostics in assessing and monitoring the status of the investigated materials.
In a 3D Terrestrial Laser Scanner the travelling time of coherent light laser pulse is converted into the distance between the instrument and the investigated object. The result of a laser scanning survey is a very dense cloud of points whose positions are known in a reference frame located in an arbitrary point inside the instrument. For each point of the surveyed target surface, the X, Y, Z coordinates and the reflectivity value are acquired and recorded, providing the area coverage necessary for the 3-D reconstruction and characterisation of the surveyed structure.
In general an interesting correlation between the spectral changes observed in the analysis of ultrasonic signals acquired in different sectors (damaged and intact) of the investigated monumental structure and those observed in the analysis of the 3-D TLS reflectivity data acquired in the same sectors was found.

The changes in spectral frequency composition of the ultrasonic and 3-D TLS data seem to be related to changes in stone material properties, but the relationship between frequency composition and rock-properties is not early as definitive. Taking these results into account further digital processing procedures and analyses on the ultrasonic and 3-D TLS data and their comparison with petrophysical aspects are now scheduled.

KEYWORDS: Ultrasonic Techniques, 3-D Terrestrial Laser Scanner, Characteristics of Stone Materials.